Three-dimensional computed tomography in acute cervical spine trauma: a preliminary report

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Abstract. Numerically integrated, three-dimensional images obtained from axial computed tomography (CT) data are vastly superior to mentally-integrated, individual, multiplanar CT images for the evaluation and diagnosis of acute cervical spine injury. This superiority results primarily from the visual display of spatial relationships. In addition, three-dimensional CT is capable of detecting injuries not found by conventional radiography or by multiplanar computed tomography (MPCT). The purpose of this preliminary report of four specially selected cases is to illustrate the superiority of three-dimensional CT over other imaging modalities (including MPCT) for the demonstration of cervical spine injuries.

Key words: Computed tomography – Three-dimensional computed tomography – Cervical spine, acute trauma – Cervical spine, injuries

The primary purpose of radiology is to provide attending physicians with the most accurate diagnostic information possible. Three-dimensional reformation of axial computed tomography (CT) data is today the most useful radiologic technique for imaging many areas of complex skeletal anatomy, particularly the spine. Except in dealing with acute intracranial abnormality, the need for absolute accuracy in radiologic imaging is perhaps nowhere more critical than in the evaluation of the acutely injured cervical spine.

It is commonly asserted that three-dimensional reformation does not provide diagnostic information which is not available from other imaging techniques [13, 15]. We contend that three-dimensional reformation does provide new insights and new, clinically significant, information regarding structurally complex cervical spine injuries. In our opinion, three-dimensional reformation of actual CT data is the most accurate method of displaying spatially complex skeletal anatomy and pathology.

Materials and methods

The four cases selected for this report are representative of other three-dimensional reformations of the same or similar acute cervical spine injuries examined in the Hermann Hospital Radiology Department since September 1986. Representative plain film and/or multiplanar computed tomography (MPCT) and three-dimensional CT images were selected to compare the accuracy of these imaging techniques. The original CT studies were obtained on a GE 9800 scanner.

The three-dimensional reformations were obtained by the three-dimensional 83 algorithm and its current updated three-dimensional 98 version produced by GE Medical Systems and developed by the Medical Image Processing Group at the University of Pennsylvania. The three-dimensional algorithm requires no modification of the usual technique for obtaining axial images other than the elimination of gantry tilt. Thus, the time of patient examination is not prolonged.

The reformations were based upon data obtained from contiguous 5 mm (case II) and 3 mm (cases I, III, and IV) axial slices through the area of interest as identified on the initial plain radiograph of the cervical spine and localized by the scout CT image. The contiguous slice technique was employed because overlapping slices provided no improvement in image resolution and tended to impede recognition of patient motion artifacts on the three-dimensional images.

In order not to occupy the CT scanner with the process of three-dimensional reformation, the axial data are transferred to an independent console (IPDC 9800) for further processing. The area selected for three-dimensional reformation includes the vertebrae above and below the predetermined area of interest. In selected cases, additional three-dimensional images of more limited areas may be created to demonstrate structures otherwise obscured by superimposed skeletal parts.

The three-dimensional program illustrated in this paper numerically integrates axial data to create the perspective of a three-dimensional image and will display these data in differ-
ent projections around any axis. The axial data may also be manipulated to create transected images at any predetermined plane. This technique will provide views unimpeded by superimposed anatomic parts. Thus, it is possible to view the spine from within the canal itself looking outward in any direction (Fig. 4g).

Our protocol requires display of images of the spine rotated around the X, Y, and Z axes (Fig. 1) in 30° increments. In every case, images were created of the entire spine through the area of interest and of each half of the sagittally transected spine. Depending upon experience, radiologists needed 20-30 min per case to select parameters for reconstruction and enter this information into the computer, according to protocol. A trained CT technologist might also select parameters. The computer requires 2-3 h to reformat three sets of images without an operator. Moreover, several cases may be processed as a “batch,” further decreasing the demand on the operator’s time.

Because the three-dimensional images are obtained from axial CT data, three-dimensional reformation may be obtained at any time subsequent to the initial CT examination and, in particular, when conventional studies and multiplanar CT are equivocal.

Results

The results of the comparison of plain film, multiplanar CT, and three-dimensional CT for each of these illustrative cases are summarized in the following paragraphs. The reader is referred to the figure legends for detailed analysis supporting these results.

A large number of images are included in order to provide a thorough comparison of plain film, multiplanar CT, and three-dimensional CT. The three-dimensional CT images are presented as they appear on the cathode ray tube or the “hard copy”. Thus, some three-dimensional CT images may be inverted, viewed through various arcs of rotation as though seen from above downward or from below upward.

In case I (Fig. 2), it is impossible to define the nature or extent of obvious atlantoaxial injury on the lateral radiograph of the cervicocranium. The multiplanar images demonstrated right anterior rotation of the occiput and the atlas with respect to the axis as well as a fracture of the right articular mass of C2. However, the frank anteroinferior rotational dislocation of C1 and the magnitude of the fracture of the right articular mass of C2 are completely appreciated only on the three-dimensional images. The high (type II) dens fracture could not be identified on the plain lateral radiograph or the axial CT, and could only be inferred on the sagittal CT, and could only be inferred on the sagittal reformation. This fracture, with displaced rostral fragment, was conclusively demonstrated in the three-dimensional image viewed from behind after numeric subtraction of the posterior arch of C1.